Appendix A.

Additional Background Information on the Fox River Headwaters Ecosystem

Excerpted from a Report Prepared by Clark Forestry, Inc.

Introduction

Much of the information compiled by staff at Clark Forestry, Inc. for this project was incorporated into the Ecological Overview in the main body of this document. This appendix contains some additional background information on ecological characteristic of the FRHE area that may be of use to some readers.

Geology

The furthest advance of the Wisconsin Glaciation forms the western boundary of the FRHE. This terminal moraine, which is also part of the northeastern boundary of Wisconsin's driftless area, was formed by the recession of the Green Bay Lobe between 15,000 and 11,000 years ago. As the glacier melted and receded northeast towards present Green Bay, it discharged outwash and left ground moraines. Large blocks of ice left buried in the till of the terminal moraine melted, forming kettle lakes (Martin, 1916).

Ninety-percent of the FRHE lies over sandstone bedrock; the balance is underlain by carbonates and volcanic rock. Across 80% of the study area the bedrock is buried under at least 50 feet of glacial drift, and it's deeper than 100 feet on nearly half of the area. Outcrops are rare: one finds bedrock within five feet of the surface on less than one-percent of the landscape. Surficial deposits are largely sand and gravel on the terminal moraine, and a mixture of outwash and wind-blown sand and lacustrine clays to the east. The FRHE is generally low and flat. Greater than 90% of the area lies below 1000 feet above sea level, and slopes greater than three percent occur on only seven percent of the landscape.

Hydrology

The study area drains into the Fox River via a number of sub-basins including the Mecan, White, Montello, and Grand Rivers; Neenah Creek; and Green, Buffalo, and Puckaway Lakes. The approximately 218 lakes within the FRHE represent about 2% of the state's total in terms of total area and number. Considering that the study area occupies just slightly more than 2% of the state's total acreage, these numbers are average. Green Lake (7,346 acres) is the largest lake in the area, and at 236 feet is the deepest natural lake in the state. The FRHE has 16 lakes listed as rare natural communities by the NHI, including excellent examples of both deep and shallow hard water lakes.

Extensive wetlands occupy the FRHE's abundant, poorly-drained glacial depressions. Out of Wisconsin's 72 counties, Marquette and Green Lake, which make up the heart of the study area, rank 11th and 4th respectively in terms of percentage of county area classified as wetland (WDNR, 2002). Wetlands occupy about one-fifth of the total acreage of the FRHE. A few of the largest, including the White River, Germania, and Grand River Marshes, are partially protected by State Wildlife Areas. About 34,000 acres, representing 17% of the total wetland area in the FRHE, is currently under state ownership.

Numerous coldwater streams, including the White and Mecan Rivers, and Wedde, Chaffee, Tagatz and Caves Creeks originate from springs along the terminal moraine in the northwest portion of the study

area. Most headwaters areas are protected by one of five State Fishery Areas that occupy some 20,000 acres.

Soils

The FRHE lies within Aldo Leopold's so-called "sand counties," which are named for the sand-dominated glacial drift that blankets the region. While the soils of central Wisconsin have been called the "Golden Sands" for their ability to produce high crop yields when irrigated (Hole, 1976), they have relatively low moisture-holding capacity and are susceptible to drought. Because water moves so easily in and out of these coarse-textured soils, associated vegetation reacts quickly to seasonal changes in moisture and temperature. If vegetation is removed, bare soil is especially susceptible to wind erosion (Hole, 1976).

Presettlement Vegetation

During the mid-1800s the U.S. Government Land Office (GLO) performed the surveys that established today's township-range-section system of property description. As surveyors moved across the landscape, they recorded the species and diameters of "witness trees" at each section and quarter-section corner. In addition, they made general observations about topography, hydrology, soils, timber, and mineral resources. Although surveyors varied significantly in their botanical knowledge, vocabulary, and enthusiasm for note-taking, their field notes represent an important snapshot of the state during the early days of European settlement.

In 1976, R.W. Finley used the GLO records to produce a 1:500,000 scale map entitled "Original Vegetation Cover of Wisconsin." This map has since been digitized and is available for analysis as a GIS coverage. Table A.1 summarizes the extent of the major presettlement vegetation types in the FRHE, and Figure A.1 shows their spatial arrangement. Oak species occurring in communities somewhere along a forest-opening-barrens continuum covered nearly three-quarters of the entire FRHE, and nearly all of the uplands. Less fire-tolerant species persisted only where topography or hydrologic features provided firebreaks. In lowland areas, open wetlands covered over seven times the area of forested wetlands.

Current Land Use / Land Cover

The Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) collected land cover data for the entire state using Landsat Thematic Mapper (TM) satellite imagery between 1991 and 1993. Landsat imagery is composed of pixels, each one representing a 30 by 30 meter square on the ground. Each pixel is assigned a value based on it's spectral reflectance, and each value is associated with a different land cover type based on the known "spectral signature" of that type. By lumping or splitting associated cover types, we can use WISCLAND to map land cover at different scales and resolutions. The final WISCLAND dataset (which uses a three-level hierarchical classification scheme) is distributed as an ARC/INFO grid file that can be quantitatively analyzed using ArcView's Spatial Analyst extension.

Table A.2 summarizes the land cover of the FRHE at all three levels of the hierarchy, and Figure A.2 shows general land cover at level one. Conversion of pre-settlement oak forests and openings to agriculture caused forest cover to decrease from nearly three-quarters before settlement to less than one-quarter today. Percentage of wetland has remained relatively constant at about 20%.

Table A.1. Presettlement Vegetation Cover of the FRHE

Vegetation Type	Acres	% of Total
Xeric Deciduous Forest white oak, black oak, bur oak	431,593	52.4%
Open Wetland marsh and sedge meadow, wet prairie, lowland shrubs	156,857	19.0%
Oak Openings bur oak, white oak, black oak	148,277	18.0%
Open Water	24,587	3.0%
Prairie	20,030	2.4%
Lowland Coniferous Forest white cedar, black spruce, tamarack, hemlock	19,733	2.4%
Brush	7,199	0.9%
Mesic Deciduous Forest sugar maple, basswood, red oak, white oak, black oak	5,528	0.7%
Mixed Deciduous/Coniferous Forest aspen, white birch, pine	4,501	0.5%
Coniferous Forest white pine, red pine	3,005	0.4%
Barrens jack pine, scrub (hill's) oak	2,208	0.3%
Lowland Broadleaved Forest willow, soft maple, box elder, ash, elm, cottonwood, river birch	40	0.0%
TOTAL:	823,558	100.0%

Table A.2. Current Land Cover of the FRHE

WISCLAND LEVEL ONE	Acres	% of Total	Level Two	Acres	% of Lev. 1	*Level Three*	*Acres*	*% of Lev. 2*
1. URBAN/ DEVELOPED	7,423	1%						
			1.1 High Intensity	3,111	42%			
			1.2 Low Intensity	3,708	50%			
			1.3 Golf Course	604	8%			
2. AGRICULTURE	267,249	32%	(Undifferentiated)	8,655	3%			
			2.1 Herbaceous/ Field Crops	258,585	97%			
						2.1.2 Corn	*106,866*	*41%*
						2.1.7 Other Row Crops	*74,892*	*29%*
						2.1.8 Forage Crops	*76,827*	*30%*
			2.3 Cranberry Bog	9	0%			
3. GRASSLAND	146,590	18%						
4. FOREST	207,317	25%						
			4.1 Coniferous	25,028	12%			
						4.1.1 Jack Pine	*1,794*	*7%*
						4.1.2 Red Pine	*20,602*	*82%*
						4.1.11 Mixed/Other	*2,633*	*11%*
			4.2 Broad-leaved Deciduous	145,019	70%			
						4.2.2 Oak	*109,676*	*76%*
						4.2.8 Maple	*62*	*0%*
						4.2.12 Other	*35,282*	*24%*
			4.3 Deciduous/Conifer	37,270	18%			
5. OPEN WATER	30,212	4%						
6. WETLAND	161,252	20%						
			6.1 Emergent/Meadow	74,102	46%			
			6.2 Lowland Shrub	38,265	24%			
						6.2.1 Broad-leaved Deciduous	*37,185*	*97%*
						6.2.2 Broad-leaved Evergreen	*883*	*2%*
						6.2.3 Needle-leaved	*197*	*1%*
			6.3 Forested	48,885	30%			
						6.3.1 Broad-leaved Deciduous	*35,689*	*73%*
						6.3.6 Coniferous	*12,446*	*25%*
						6.3.10 Mixed Decid./Conif.	*750*	*2%*
7. BARREN	2,374	0%						
8. SHRUBLAND	1,061	0%						
TOTAL:	823,478	100%						

Ecoregions

An ecoregion is a geographic area that has a relatively consistent pattern of topography, geology, soils, vegetation, natural processes, and climate. The most widely-used ecoregion classification scheme is the U.S. Forest Services "National Hierarchical Framework of Ecological Units" (NHFEU) (Bailey, 1995 and Keys, 1995). This system divides North America into four "ecosystem domains"; each domain is further divided into "divisions," "provinces," "sections," "subsections," and "landtype associations."

DNR Ecological Landscapes
In order to provide Wisconsin resource managers with a simple ecoregion classification customized for their state, the DNR grouped NHFEU subsections to form 17 distinct "ecological landscapes" (ELs). Ninety-three percent of the FRHE lies within the Central Sand Hills EL; the Southeast Glacial Plains EL (about 50,000 acres in eastern portion) and the Central Sand Plains EL (less than 1000 acres along the terminal moraine) occupy the balance. The Central Sand Hills EL is composed of two NHFEU subsections: a broad kettle moraine in the west (subsection 222Kb) and a relatively flat area of pitted outwash in the east (subsection 222Kd). Landtype associations (LTAs) are the finest level of the ecoregion hierarchy, but since there is currently very little published information at the LTA level, the descriptions that follow are written at the subsection level.

NHFEU Subsections
Wisconsin is divided nearly in half along the tension zone by two ecosystem divisions: the Warm Continental (210) in the north and the Hot Continental (220) in the south. The FRHE lies just south of that boundary, entirely within the Hot Continental Division, the Eastern Broadleaf Forest province (222), and the Southwestern Great Lakes Morainal section (222K) (Keys, 1995).
Five distinct subsections occur within the FRHE (see Figure A.3):

222Kb: Central Wisconsin Moraines and Outwash (512,192 acres, 62% of FRHE)
Sandy pitted outwash, steep terminal moraine, and rolling ground moraine topography characterize this subsection. Northern pin oak forest, bur oak openings, and big bluestem-Indiangrass prairie dominated this area in presettlement times and represent the best opportunities for restoration. Kettle lakes, ponds, and wetlands are abundant because of the frequent glacial depressions.

Soils are sands and loamy sands on the outwash, and loamy sands to sandy loams on the moraines. Center pivot irrigation has allowed for cultivation of most of the level sand plains, while oak forests dominate areas that are poorly suited to agriculture. Rare natural communities include oak barrens, wet mesic prairies, calcareous fens, and coastal plain marshes (Albert, 1995). Nearly 34,000 acres representing 7% of the subsection is under state ownership.
LTAs: 222Kb01: Arnott-Almond Moraine Complex, 222Kb03: Wild Rose-Wautoma Moraine Complex, 222Kb04: Coloma Plain, 222Kb05: Buffalo Lake Outwash Channels, 222Kb06: Lewiston Basin, 222Kb07: Portage Floodplain

222Kd: South Central Wisconsin Prairie and Savanna (257,352 acres, 31%)
This subsection is primarily rolling to hilly ground and end moraine topography made up of sandy outwash, loamy till, and clayey lake deposits. Prior to settlement bur oak openings dominated in areas without significant firebreaks, while white oak-red oak forests occupied sites protected by streams or wetlands.

Today nearly all of the level ground in this subsection is cultivated. Forests persist almost exclusively in areas where excessive slope or poor drainage makes agriculture impractical. Oak openings (savannas), wet mesic prairies, wet prairies, and calcareous fens are the most significant rare natural communities (Albert, 1995). The state owns just over 2% of this subsection.

LTAs: 222Kd01: Rio Moraines, 222Kd02: Green Lake Moraines, 222 Kd04: Pardeeville Plains 222Kd07: Princeton Drumlins, 222Kd08: French Creek Moraines

222Kc: Lake Winnebago Clay Plain (49,276 acres, 6%)
Flat lake plains and ground moraines reworked by glacial lakes characterize this subsection, which extends into the northeastern part of the FRHE. Red clay soils dominate, and are high in carbonates because of the dolomitic rock that underlies the area. Sugar-maple basswood forests dominated this subsection prior to settlement, but oak openings and forests were common on the portion within the FRHE because of high fire frequency (Albert, 1995). Extensive wetlands and agriculture dominate the area today. Nearly all of the 17,000-acre White River Marsh Wildlife Area lies within this subsection, which is 31% state-owned within the FRHE.
LTA: 222Kc07: Redgranite Lake Plain

222Ke: Southern Green Bay Lobe (3,784 acres, < 1%) **and**
222Ra: Central Wisconsin Sand Plain (954 acres, < 1%)
These subsections occupy very small areas at the margin of the study area. The Central Wisconsin Sand Plain is set apart by it's largely unglaciated, nearly level topography. The Southern Green Bay Lobe occupies a large glaciated area of southeastern Wisconsin extending from the lower Fox Valley to west of Madison. A complex of ground moraines, terminal moraines, and lake plains of sand and silt loam characterize the area.
LTAs: 222Ke12: Beaver Dam Drumlins, 222Ra08: Plover-Hancock Outwash Plain

References

See Appendix B for a full reference list from the Clark Forestry Report.